POOR LEGIBILITY

ONE OR MORE PAGES IN THIS DOCUMENT ARE DIFFICULT TO READ
DUE TO THE QUALITY OF THE ORIGINAL

Safe Operation Of Solvent Degreasers

. . . In spite of bad practices in many plants it has been proved that degreasing can be efficient, economical and entirely safe, if a few simple rules are followed. The few instances of trouble have been traced to a lack of knowledge and understanding of the properties of the solvent, or the proper operation of the equipment, both phases of which the author covers in this article.

o o o

By L. P. LITCHFIELD

Service Manager, Solvents Div., Electrochemical Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

o o o

SOLVENT degreasing became established during prewar years as a standard cleaning procedure but the suppliers of the equipment and chemicals have been able to furnish new and improved machine designs and operating techniques to meet the vastly increased production required by the war. Thousands of new degreasers have been manufactured for war production. Inexperienced hands have often installed the machines and operated them. Normal supervision and control have not always been possible, and the order of the day has been production with little emphasis on cost accounting. Despite these conditions there have been comparatively few troubles, due largely to the inherent soundness of the process and equipment.

Essentially a degreaser consists of a tank to which heat is applied at the bottom to boil the solvent within the tank. Trichlorethylene is the principal solvent used in the process, but perchlorethylene may be advantageously used in some cases. Vapors are held within the machine by a condenser placed around the inside walls near the top and the distillate drains into a trough which carries it back to a storage tank or another compartment of the machine. The work is suspended in the vapor zone so that the pure liquid solvent is condensed from the vapors, rinsing the parts free from grease or oil. If stubborn insolubles must be removed, the work may first be immersed in boiling or warm solvent or it may be sprayed with warm solvent. In every case, however, the work leaves the machine through the vapor level and is washed with condensed, uncontaminated solvent. The work remains in the vapor zone until condensation of the vapor stops. At this point the work has reached the temperature of the boiling solvent. It is then raised above the vapor level where it quickly dries before removal from the machine.

Trichlorethylene is a very dense liquid, being nearly one and a half times as heavy as water. Its vapors are four and one-half times as heavy as air. This makes it possible to maintain a definite vapor line in the degreasing machine and keeps losses into the air at a minimum. The boiling point is comparatively low (188 deg. F.) which permits the use of low steam pressures and also simplifies the removal and handling of the work after cleaning. Because of the low latent heat of the solvent, metal parts condense large quantities of the vapor. The latent heat of trichlorethylene is 103 B. t. u. per lb., less than 1/9 that of water. This means that a metal part will condense more than nine times as much trichlorethylene by weight as it would steam. In addition, the low latent heat requires much lower cooling capacities and heat input for machine operation and solvent recovery.

The corresponding properties of perchlorethylene are similar to those of Tri, with one major exception. The higher boiling point of Per (250 deg. F.) requires higher steam pressures and necessitates special care in handling the hot work on leaving the machine. In addition, some alloys may be adversely affected by the higher temperature of the boiling solvent and vapor.

An important characteristic of both Tri and Per is non-inflammability at ordinary temperatures. The chemicals do not produce a flash by either the closed cup or open cup method.

Toxic Chemicals Employed

Because degreasing employs a toxic chemical, care must be exercised in the operation of the process. All of the chlorinated solvents act as narcotics and inhalation of the vapors may produce nausea, dizziness, headaches, and a general ill feeling. Trichlorethylene and perchlorethylene, being the least toxic of the chlorinated hydrocarbons, however, are rapidly eliminated from the body, and these symptoms will disappear quickly on access to fresh air. From existing medical knowledge, it can be assumed that no permanent effects on the functional organs will be found even after repeated exposure of short duration to fairly high concentrations of vapor.

The acute or immediate effects of

Iron Age March 1, 1945 (58-

excessive exposures to any toxic materials are often revealed in the form of fatigue, and this is true with Tri or Per. Workmen may attribute this fatigue to overwork or to some common ailment. Indeed, the effects are much more noticeable when the individual is over-tired, has not eaten properly, is in need of sleep, or the victim of a cold, hangover or other malady. A healthy person is less susceptible than one who is not so sound. Early effects must not be ignored if harmful exposures are to be avoided. Unconsciousness resulting from extreme exposure should be treated by artificial respiration, preferably under the direction of a physician.

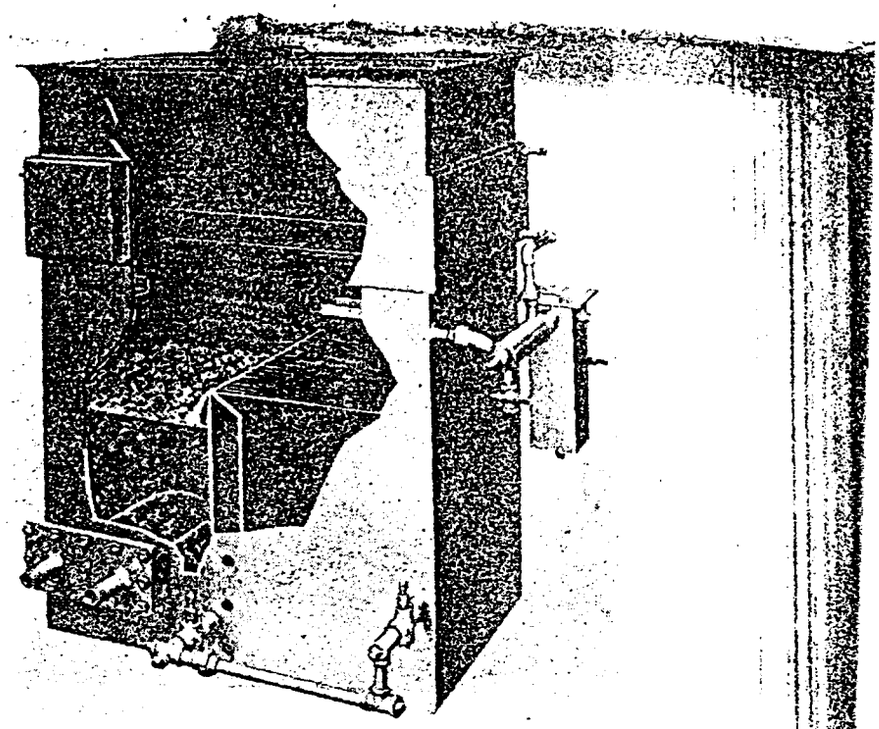
Frequent contact of the skin with either solvent may produce excessive dryness due to the extraction of natural oils. Very dry skin may, of course, crack open and invite infection.

Because of these potential hazards, the solvent should be used only in equipment designed for the purpose. Modern degreasers that are properly maintained are regularly operated without endangering the health of the workers.

Occasionally a workman will find pleasure in the psychic effects of inhaling the vapors. Such individuals may be inclined to handle solvent or operate equipment carelessly, and should be changed to other work.

The "maximum allowable concentration" of trichlorethylene or perchlorethylene for an 8 hr. working day, suggested by the State of Massachusetts and accepted by most hygiene authorities, is 200 parts per million. (See Table I.) The validity

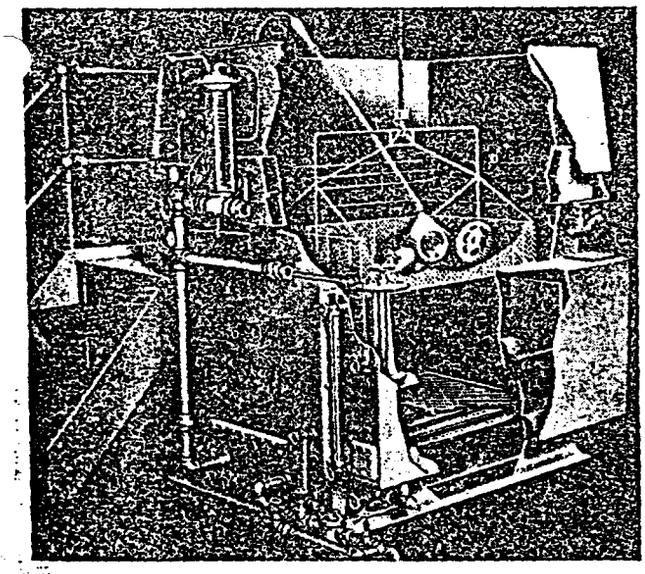
o o o



RIGHT

TWO compartment degreaser, steam-heated. This cutaway view illustrates the principle of degreasing in which solvent vapor is condensed, drained into the trough and then into the unheated compartment. The work is first immersed in boiling solvent, then in clear warm solvent, then raised through the vapor for final cleaning.

o o o



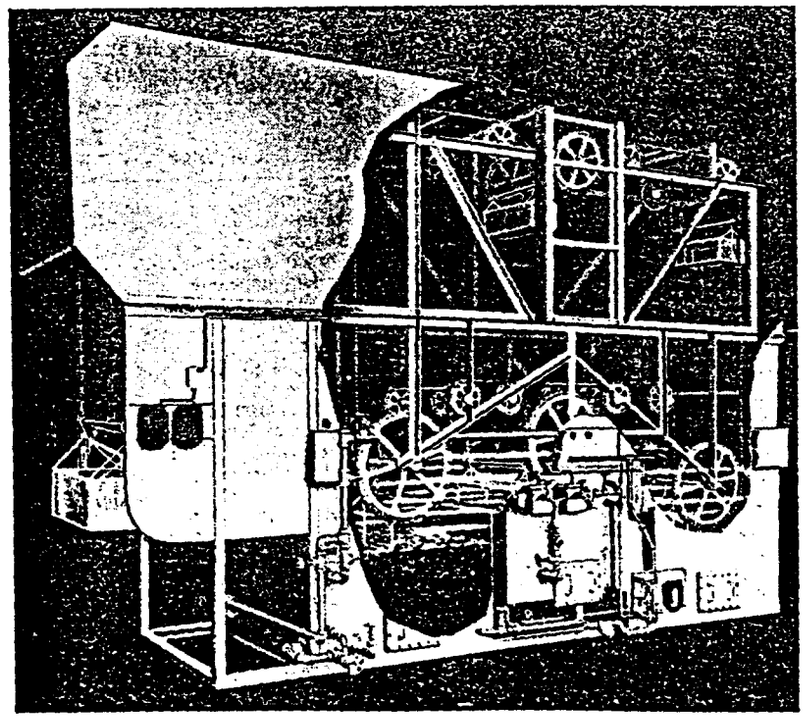
LEFT

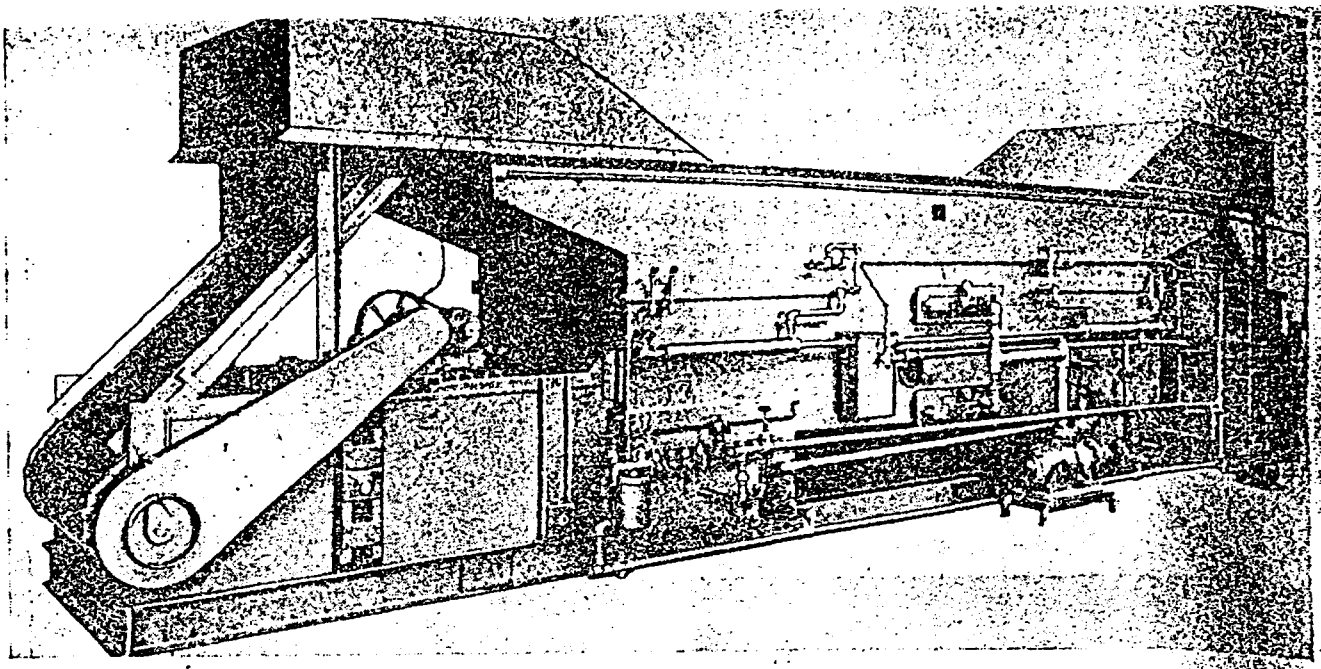
STEAM-HEATED vapor-spray-vapor machine. Basket of work, lowered by an electric hoist, is being sprayed below the vapor line prior to a final rinse in the vapor. During idling periods, vapors are condensed, drained into the trough and then into the storage tank. Pump delivers this clean solvent to the spray lance when required.

o o o

BELOW

THREE-COMPARTMENT conveyorized machine, fully enclosed. By means of the cross-rod conveyor system, the rate of entry and removal of the work is exactly controlled.





VAPOR-SPRAY-VAPOR degreaser with mesh conveyor, fully enclosed. In this machine, small parts are cleaned without handling or loading into baskets.

of these so-called "threshold limits" is supported by recent research of Seifter (9) and by the work of Carpenter (10).

It is fundamental that if a degrease is to be operated safely, it must be designed and constructed along sound engineering lines. Experience has shown that it does not pay the user to attempt to build a degreaser since homemade machines invariably cause trouble. A machine should not be designed and recommended by the manufacturer for each particular job. The kind and amount of work to be cleaned and the cleaning requirements must be considered. In addition, the manufacturer can assist in planning for the most desirable location in the production line for efficiency and safety.

It is true that most safe practices will also provide efficiency. This is a happy situation for the safety engineer whose rules and regulations must necessarily not hinder production and the quality of the work.

Machines are designed with due regard for production requirements, with particular emphasis on heat input, condensing surfaces, thermostatic controls, water separators and cleanout doors. The design of racks is especially important to minimize the load on the machine and allow for racking the work to avoid liquid drag-out. Hoists, preferably electrically operated, are provided to raise and lower the work at slow speeds.

Installation Factors

Installation should be carefully supervised to make sure that a suitable location is chosen and that proper piping connections and mechanical adjustments are made. Safety devices must also be set in accordance with the best practice. Many points must be covered in installing degreasing equipment to insure safety and efficiency. The machine should be located in a large room, free from drafts and at some distance from open flames or hot surfaces. The height of the machine above the working floor level must be carefully planned and if the machine is installed in a pit, the area should be mechanically ventilated and of sufficient size for convenient maintenance. Steam pressures must be properly established or gas burners provided with flues installed, according to accepted safety rules.

Except for ventilating pits, exhaust ventilation is not ordinarily necessary. In special cases where, for one reason or another, good practices are inoperative or ineffective, mechanical ventilation may be advisable. Such facilities should be provided only after consultation with the manufacturer of the machine. All such exhausts should, of course, be disseminated outside the building.

At a conspicuous location near each degreaser, a suitable operating instruction card should be permanently posted. Safety precautions should be included. In addition, a warning plate of ceramic finish or other durable material should be permanently placed on the machine in the most conspicuous position. This plate should warn of the toxic nature of the solvent and of the danger of entering the machine for cleaning.

To avoid back-pressure, water outlets from condensers should never be connected directly to sewer lines, but installed so as to drain into an open-

TABLE I

Code for Maximum Safe Concentrations of Some Common Toxic Substances

Suggested by the State of Massachusetts*

Gas or Vapor	Parts Per Million
Ammonia	100
Aniline	5
Benzene	75
Carbon bisulfide	15
Carbon monoxide	100
Carbon tetrachloride	100
Chlorine	1
Ether	400
Ethylene dichloride	100
Gasoline	1000
Hydrochloric acid	10
Methanol	200
Phosgene	1
Sulfur dioxide	10
Tetrachlorethane	10
Tetrachlorethylene (perchlorethylene)	200
Toluene	200
Trichlorethylene	200
Turpentine	200

* From Journal of Industrial Hygiene & Toxicology, Volume 22, 1940—Page 251.

sight device such as a funnel. This is one of a multitude of special piping connections which only a specialist can be expected to know.

Needless to say, when repairs or relocation of a machine are being considered, all of the requirements of an original installation must be met. In no case should welding be attempted on any part of a degreaser until all solvent has been removed and the machine thoroughly ventilated.

Operation of Degreasers

Before a degreaser is used for routine production, the manufacturer's representatives should instruct operators, foremen and department heads in the procedures for operating and periodically cleaning out the machine. If possible, one person should assume responsibility for supervision of degreasing operations. Also it is preferable for only one man to operate a machine on each shift.

The most important point for degreaser operators to remember is that each machine has been designed for a specific type and volume of work. The method and speed of handling and the size of work loads should not be changed without previously consulting the machine manufacturer.

The machine should be operated so as to create a minimum disturbance of the vapors. If excessive loads are handled, a drop in vapor level will result. Consequently, air will be sucked in and mixed with solvent vapor. When the vapor line is gradually restored, these mixed vapors will be forced out of the machine, and will contaminate the surrounding air. Work should be entered and removed as slowly as possible and should remain in the vapor until it has reached the vapor temperature, as evidenced by the stopping of condensation. The maximum vertical speed should be about 11 ft. per min. Wherever possible, electric hoists should be used. Slushing or spraying must be carried out with the nozzle well below the vapor level in order to minimize vapor disturbance. In being transferred from one compartment to another, the work should be moved below the vapor line, if possible.

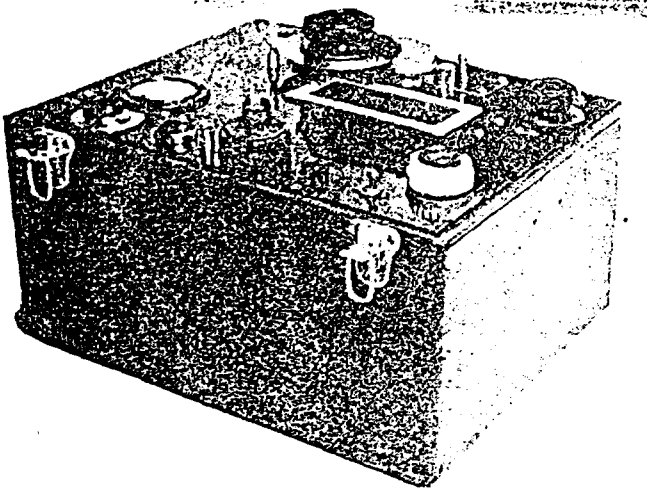
All work should be thoroughly dry before removal from the machine. At proper speeds of removal, heavy parts having small surface areas can be withdrawn continuously. However, work with large surface areas, notably baskets of small parts, requires extra time in the freeboard zone before removal.

The level of the boiling solvent should never be allowed to drop below the tops of the heating surfaces, as overheating of the solvent may result. When solvent is added to a degreaser, care must be taken to avoid splashing due to expansion on striking heated surfaces or hot solvent-oil mixtures.

In order to avoid condensation of moisture, the water temperature at the condenser outlet should be maintained above the dew-point of the atmosphere (about 100-120 deg. F.). The water should always be turned on before heat is applied; in shutting down the degreaser, the water should be turned off last.

Operation can continue until the solvent is severely contaminated, although a regular frequency of cleaning is ordinarily recommended. In many cases the cleanout cycle will be determined by accumulation of metal chips or powder. Sometimes the amount of dissolved oil will be the controlling factor. As the oil content of the solvent increases, its boiling point is raised, making distillation more difficult. Curves are shown for trichlorethylene and perchlorethylene, indicating the elevation of boiling point caused by increased percentages of mineral oil. The temperature of the boiling, dirty solvent is thus an indication of the contamination. Cleanout is advisable when the temperature reaches about 195 deg. F.

o o o

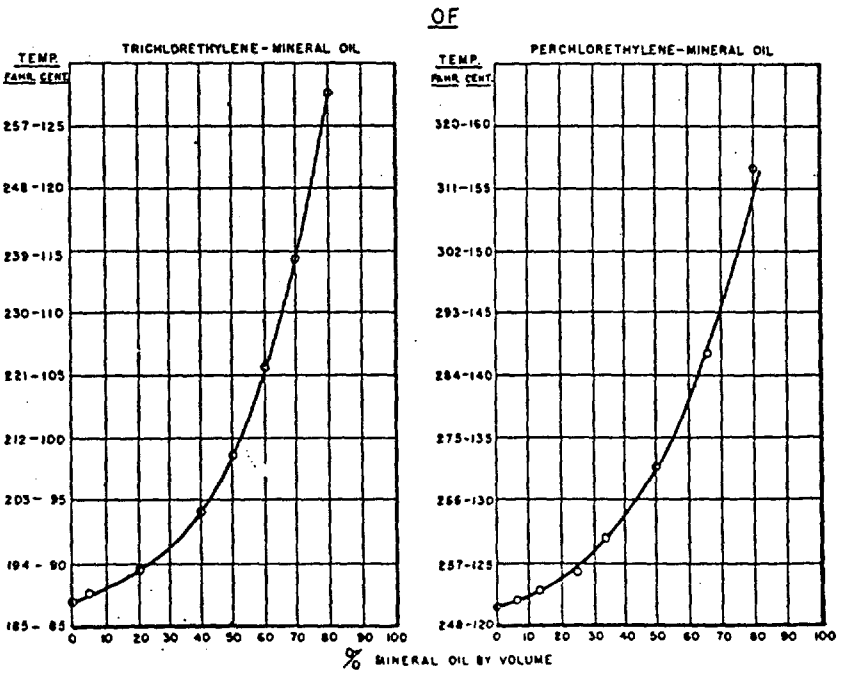


ULTRAVIOLET photometer used for measuring solvent contamination of air in the working area. Sensitive to both trichlorethylene and perchlorethylene, this instrument makes possible immediate recognition of concentrations of vapors that may be unhealthful. It is made by the Mine Safety Appliances Co., Pittsburgh.

o o o

o o o

INCREASE in boiling point of trichlorethylene and perchlorethylene mixed with various percentages of mineral oil. The fact that the boiling point rises is an index of the contamination of the solvent.



...for perchlorethylene. These figures correspond to oil concentration of about 30 per cent by volume.

Recovering Solvent

Solvent can be completely recovered from oil residues if proper equipment and procedures are used. The best practice is to use a still especially designed for the purpose. Residues may be piped directly to the still from the degreasing machine, eliminating air contamination and handling by the operator. Transporting solvent or solvent-bearing residues in open containers should be avoided, particularly when they are hot, and proper masks should be used if solvent vapors are to be encountered. Solvents can also be recovered by distillation in the degreaser itself.

If solvent is reclaimed in a gas or electric machine, the temperature of the residual oil may reach its flash point. If low-flash oils are involved, an advisable precaution against fire is to extinguish gas pilot lights before draining the machine.

Under no conditions should water be added to boiling solvents, as a flash distillation may occur. The steam distillation temperature of trichlorethylene is 164 deg. F.; of perchlorethylene, 190 deg. F.

Cleaning Out the Degreaser

After solvent residues have been drained off, the cleanout doors should be opened and the machine cleaned from the outside. *If a large unit must be entered for cleaning, this should be done only after all solvent liquid and vapors have been removed or dissipated, and then only with at least one other workman in attendance on the outside.* A workman entering a machine for any purpose should wear a mask which provides a supply of outside air.

The addition of soda ash or trisodium phosphate to water is sometimes recommended for boiling out degreasers prior to recharging. *Caustic soda (sodium hydroxide) should not be used.* A final flush with hot water will leave the machine ready for recharging with clean solvent.

Each degreaser installation should be regularly inspected by experienced technicians to check the overall conditions of the tank and all of its control devices. Methods of operation and the observance of good safety practices should be covered at the same time. Routine maintenance is as important for a degreaser as for any piece of operating equipment, and will pay dividends in overall costs and process efficiency.

TABLE II

Possible Sources of Waste of Solvent in Degreasing Operations

- Losses into atmosphere from improper heat balance or improper cooling control
- Drafts over the degreaser
- Improper handling of work:
  - Racks too large
  - Poor racking of parts—liquid dragout
  - Use of wooden racks or rope slings
  - Too rapid entry and removal of work
  - Slushing above vapor line
  - Removing work from vapor too soon
  - Removing small parts (cleaned in bulk) from freeboard area before completely dry
- Covers off during idling
- Loss of solvent and stabilizers during distillation
- Throwing away residues containing solvent
- Losses due to poor housekeeping, necessitating frequent recharging of machines with new solvent
- Leaks in pumps, valves, etc.
- Excessive moisture in machine
- Drop in vapor line due to excessive loads, heavy racks, low heat input, etc.
- Cleaning overalls or other garments in the machine.

Conservation of Solvent

In Table II is a list of possible sources of waste of solvent in degreasing operations. Operators should check all of these possibilities in order to insure lowest operating and maintenance costs and highest cleaning efficiency, and to eliminate potential health hazards.

If the air surrounding a degreaser becomes contaminated with solvent vapor so that the odor is bothersome, there is always a reason, and the cause can be readily determined by a simple study of the operation. When the safety of workmen is questioned, it is sometimes helpful to measure the amount of vapor in the working area. A rapid analyzer for trichlorethylene and perchlorethylene has been developed by du Pont engineers (see cut). This instrument, known as the Tri-Per Analyzer, may also be used for some other vapors. Measuring concentrations of solvent vapors in the air throughout the cleaning cycle not only makes it possible to establish the comparative hazard to the workman; it also assists in pointing out high concentrations at certain periods in the cycle. The specific cause for temporarily high values, such as drafts across the machine, too rapid entry or removal of the work or withdrawal of liquid solvent on the work, can be quickly detected and shown as parts per million of solvent in the air.

Solvent degreasing has been widely ...parts of all kinds are fabricated, finished or assembled. The rapid expansion of degreasing facilities during the war is an indication of postwar potentialities. Wartime experience in thousands of plants has demonstrated the practicability of the process. In spite of bad practices in many plants, and in spite of frequently inadequate and inexperienced personnel, it has been proved that degreasing can be efficient, economical and entirely safe, if a few simple rules are followed. Considering the large volume of work that is degreased throughout the country, there have been comparatively few accidents due to the toxicity of the solvent. This is particularly noteworthy because the process is new in terms of years and in view of the recent rapid increase in usage. The few instances of troubles have been traced to a lack of knowledge and understanding of the properties of the solvent, or the proper operation of the equipment. These difficulties are rapidly disappearing as all concerned become better acquainted with this tool for increased production and more efficient cleaning.

BIBLIOGRAPHY

Degreaser Operation

(1) Operating instructions supplied by G. S. Blakeslee & Co., Chicago, and Detrex Corp., Detroit.

(2) "Metal Degreasing with Chlorinated Solvents—Standard Practices." E. I. du Pont de Nemours & Co., Inc., Solvents Division, Electrochemicals Department, Sept., 1944.

Chlorinated Solvents

(3) "Du Pont Chlorinated Hydrocarbons Bulletin"—1944 Edition.

(4) "Chloro-Hydrocarbon Solvents," by E. W. McGovern, Industrial & Engineering Chemistry, Vol. 35, Dec., 1943, p. 1230-1239.

Toxicity of Solvents

(5) "The Halogenated Hydrocarbons: Their Toxicity and Potential Dangers," by W. F. von Oettingen, *The Journal of Industrial Hygiene and Toxicology*, Vol. 19, No. 8, Oct., 1937, p. 349 to 448.

(6) "Toxicology and Hygiene of Industrial Solvents," by K. B. Lehmann and F. Flury (a translation by E. Kane and F. M. Smith from the German); Williams and Wilkins, Publishers, 1943. (378 p.)

(7) "Toxicity of Industrial Organic Solvents"—Summaries of Published Work, Report No. 80, His Majesty's Stationery Office, 1937. (396 p.)

(8) "A Comparison of the Toxicity of Carbon Tetrachloride and Trichlorethylene," by H. M. Barret, D. L. MacLean and J. C. Cunningham, *The Journal of Industrial Hygiene and Toxicology*, Vol. 20, No. 5, May, 1938, p. 360 to 379.

(9) "Liver Injury in Dogs Exposed to Trichlorethylene," by Joseph Seifter, *The Journal of Industrial Hygiene and Toxicology*, Vol. 26, No. 7, Sept., 1944, p. 250 to 252.

(10) "The Chronic Toxicity of Tetrachlorethylene," by Charles Patten Carpenter, *The Journal of Industrial Hygiene and Toxicology*, Vol. XIX, No. 7, p. 323 to 336.

6499